

## PSYCHOLOGICAL FACTORS IN ACCIDENT CAUSATION.

*Paper presented to the Institution, Birmingham  
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In the introduction the author states that "psychological factors are prominent in the causation of the majority of accidents." The value of the individual's personal "defence mechanism" is mentioned, and a psychological analysis of why men have accidents is made. Safety habits and accident proneness are considered in detail, and the paper ends with a section devoted to "Stupidity and perversity." The discussion covers a very wide field of accident causation, including psychological and environmental factors.

**T**HERE is an obvious approach to the problem of reducing factory accidents. It is to make them impossible. Nowadays, however, we realize that that cannot be done. An estimate has been made that, even if the perfect safeguarding of machinery was achieved, the consequent fall in the number of accidents would be in the region of only another 10%. Other accidents, caused, for instance, by stumbling and slipping, by dropping things, and by day-dreaming when using hand tools would go on happening as before. And, while we go on trying within the limits of our powers to make accidents impossible, we have to seek out other ways of approaching the problem.

Some investigators say that as many as 80% of the accidents occurring in factories, in homes and on roads are due to mistakes made by human beings. Estimates of that sort are usually unreliable, and I know that not everyone is prepared to accept them. Few will disagree, however, with the statement that psychological factors are prominent in the causation of the *majority* of accidents. And, while I am on this point, may I remark that far more accidents occur each year than most of us realise. I have seen one estimate that almost half the people in Great Britain have an accident requiring first-aid treatment every year. The common reply to that is, "But a great many of them must have been quite minor accidents." That is, of course, so; but what are the chief differences between major and minor accidents? They are in the consequences. Minor accidents are merely those accidents which by good luck did not have serious consequences.

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### A Psychological Conflict.

The fact that we listen to details of accident frequencies without being alarmed for our own safety points to the existence within us of a defence mechanism. We regard these details of accident frequencies from the detached standpoint of a spectator. The accidents happened to other people, not to us.

One of the fundamental elements in our psychological make-up is the disposition to shut out from ourselves facts which would disturb us very much. To some extent they are repressed, and we are aware of them subconsciously; but it would seem that we may completely overlook them, just as in an argument we may fail to comprehend a contrary point which is not closely associated with our own opinions.

This protective attitude is, however, essential for the preservation of mental stability. It does not follow that, if we made an individual thoroughly frightened about his personal safety, he would be less liable to have accidents. Possibly—perhaps probably—he would be more liable to have them. Accordingly, this defence mechanism is not a thing to be tampered with lightly.

But its existence is a great handicap to everyone engaged in safety work. It is reflected, for instance, in the tendency to attribute the causes of accidents to chance—acts of God—just because they were unforeseen and unintentional. There has been, of course, a considerable change for the better in recent years. The callous disregard of the Victorians has gone. But the fact that sepsis supervenes astonishingly frequently shows that there is still much indifference on the part both of employers and of employees.

### Why Men have Accidents.

We may say of a man who has caused an accident that—

- (a) he was unaware that he was running a risk and was unable to or did not take the necessary precautions;
- (b) he was aware that he was running a risk and was unable to take the necessary precautions;
- (c) he was aware that he was running a risk and did not take the necessary precautions.

All of these are of interest to psychologists, and I propose to sketch the various aspects under the three headings, and then to deal with them in more detail.

- (a) It does not follow that because a man did not know he was running a risk he could not have taken precautions against being hurt. He may have already formed a safety habit, such as looking both ways before stepping from the pavement on to the roadway; and so, without any conscious realization of what he was doing, have avoided being knocked down.

- (b) It is improbable that men are still called upon to do a hazardous job without being provided with any kind of protection. Whether the protection is entirely satisfactory and whether they are really guarded against all eventualities is perhaps less certain. I shall not treat this as a psychological aspect of the subject, although there are admittedly some grounds for doing so. By the same token I shall exclude discussion on points related to environmental conditions—such as inadequate illumination which prevents the worker from seeing quickly; faulty lighting which dazzles him by glare and deceives him with shadows; and coldness which reduces his manual dexterity.

A man may realize that he is running risks, and yet because of a weakness within himself be incapable of taking adequate precautions. His manual dexterity may be low even though the air conditions in the room are hot rather than cold. Clumsy-handed people are, however, not often allocated to dangerous work. Less easily detected is sluggish sensori-motor co-ordination—some people react much more quickly than others to visual, auditory or other signals—that is to say, they are much more able than others to get safely out of awkward predicaments.

Not only, however, may a person in an unexpected happening be involved in an accident because his reactions are too slow. He may be incapacitated by a physical weakness, such as high blood pressure. He may have a nervous temperament, and become flurried. Or he may not know what is the right thing to do—that is to say, his accident is attributable to faulty training. On the other hand his training may have been on the whole efficiently carried out, but he may have developed a defective method of working, perhaps undetected by others or by himself, which leads him to keep on doing one particular thing or group of things in a dangerous way. Particularly puzzling are the cases of men who make a mistake in work which they have done regularly and thoroughly for many years. Whatever may be the actual explanation, it will probably have something to do with distraction of attention.

- (c) In all of these cases the worker, if he had been able to protect himself, would have done so. But sometimes it would seem that he just did not bother to protect himself. Why? The explanations are of two orders—stupidity and perversity. Stupidity may be attributed to low-grade intelligence or to some kind of recklessness. Perversity may be attributed to a comparatively simple behaviour tendency, such as contra-suggestibility, or to a more complex tendency, such as social unco-operativeness.

### **Safety Habits.**

There is a general safety habit besides a great many specific safety habits. The general safety habit—caution when caution is needed—is very different from the evasion of responsibilities associated with cowardice, and from the timidity with which the faint-hearted do tasks which they think may involve them in personal danger. I sometimes wonder what part this timidity actually plays in the disturbingly large number of accidents young persons meet with in industry. I remember in the days of my own apprenticeship one or two youths being in a “funk” about doing certain jobs. It is conceivable that, had a dangerous situation developed while they were doing them, they would have been so terror-stricken that they would have been incapable of protecting themselves.

The approach in inculcating the general safety attitude is through propaganda—posters, slogans, display of tables of accident frequencies, film shows, etc. A reference should be made here to the part which schools can play in fostering this general attitude.

Almost all jobs—commercial and sales as well as industrial—have dangerous aspects. For instance, a clerk may trip over a telephone wire, a typist may fall down a particular stairway, a warehouseman may tumble off a ladder, a sales assistant may tear a finger on a piece of wire. In every job there are hazards of this sort. Once they are recognized it may be a fairly simple matter to form a safety habit to avoid them. Only too frequently, however, when an accident of this sort happens, it is thought to be either too trivial to bother about, or to be due to mere chance and so to be quite unpreventable.

One of the chief difficulties encountered by safety committees and safety officers when trying to instil safety habits in the workers' minds has been commented on by many factory managers—“You can't protect the men against themselves.” I have never accepted the view that it is professional pride which leads workers to scoff at safety campaigns and in particular at safety devices. More probably is it fear of ridicule. For instance, a worker who does not put on a safety-belt when leaning out of a window may be subconsciously if not consciously afraid that fun will be poked at him if he uses it.

This approach is therefore largely a matter of education. And education is a slow process. But solid progress has been made in this direction during the last twenty years.

### **Accident Proneness.**

The next three topics—sensori-motor co-ordination, physical incapacity, and nervous temperament—may be discussed together under the heading of Accident Proneness.

This aspect of the subject has received much attention during the last few years, largely because it has been proved that some persons are more prone to suffer accidents than others. It should be noted, however, that this in itself does not justify the assumption that each individual has a characteristic degree of accident liability. There are other possible explanations, such as that having one accident increases liability to have others, perhaps by making the sufferer too apprehensive or resentful, especially if there has been delay and haggling over his compensation. And may I say, in passing, that so far too little attention has been given to after accident effects, particularly in cases of sudden and frightful accidents. Or the explanation may be found in faulty selection or training, or in the frequent repetition of a mistake. The opinion held in psychological circles, however, is that even after there have been removed from a group of apparently accident prone people those whose bad accident record can be explained in any other way, there will remain a core, perhaps quite small, of people who are really accident prone in consequence of a personal characteristic.

You will find in the annual report of the Industrial Health Research Board for the year ended June, 1938, an account of some of the work done by the Board's investigators on this question. There it is said that, "given equal exposure to risk, roughly three-quarters of recorded accidents happen to one-quarter of the people exposed to them; and that this holds true for factory accidents, road accidents and accidents in the home—even for the chances of getting a speck of dust in the eye."

What is this personal characteristic? The report says that not all the factors are known, but quickness of muscle reaction is certainly one of them. The report also expresses the belief that the use of sensori-motor tests would appreciably reduce the accident rate of boy apprentices to skilled trades.

Certain physical incapacities, such as defective eyesight and hearing, undoubtedly tend to increase accident proneness; but I do not know that there is yet any evidence to justify the impression held in some quarters that high blood pressure and kidney disease may be associated with proneness to have accidents.

I am personally much interested in the suggestion that people who have a tendency to "lose their heads" may be prone to have accidents. Tests of the capacity not to get flurried are used by certain stores when selecting sales assistants, but I have never heard of these tests being used to measure accident proneness. It is a perplexing subject, for, while I think we may claim that we are on fairly sound ground when we test abilities such as I have just mentioned, little worth-while progress has yet been made towards the reliable measurement of temperamental characteristics by means of tests.

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Outstanding among the other possible explanations of accident proneness is undoubtedly faulty training. Much industrial training still shows little advance on the "picking it up" which we associate with Victorian days. Accidents suffered by young persons sometimes give point to this criticism. For instance, in the Chief Inspector of Factories' Report for 1937 there is mention of a boy who was set to work at a machine without having any instructions even as to starting and stopping the machine. Within a few hours he lost a finger. Another case is that of a charge-hand watching a boy trying with a crowbar to loosen the spring guide of a planing machine while it was in motion. The boy's left hand was badly crushed.

### **Movement Study.**

Now this goes further than the previously mentioned subject of inculcating safety habits, for it raises another question. To what extent have the methods used by craftsmen at their work really been planned to eliminate wasteful and misapplied effort? In the case of highly mechanized processes the answer may be that they have been well planned, for many of the designers of modern machinery realize the importance of accommodating the persons who are to operate the machinery. But other processes, particularly hand processes, are often done in a slipshod way. This remark may be applied, incidentally, even to those men and women who have remarkable skill at a very fine operation. The arrangement of tools and parts on their benches is frequently slovenly, and their environmental conditions most unsatisfactory.

During recent years the greatly increased application of time-and-motion study in British factories has focussed attention on the need for improving methods of work. Unfortunately, however, the emphasis in time-and-motion study is usually put on the times, for it is related to the setting of financial incentives. It may, indeed, have an incidental effect of stamping in an unsatisfactory way of working rather than of casting it out. Industrial psychologists are, accordingly, of the opinion that, if more attention was given in factories to removing the hindrances which prevent employees from doing the best work in keeping with their capacity, there would be a distinct improvement in efficiency and that simultaneously there would be a reduction in the number of accidents.

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The most perplexing industrial accidents are those experienced by the trustworthy worker who makes an incredible mistake in a routine job he has done satisfactorily for many years. The explanation in these cases has clearly to be found outside of the job itself. Sometimes the injured man is able and willing to say what has "upset" him—perhaps he is worried about a member of his family

who is ill, or about becoming involved in debt. This points, incidentally, to the harm which can result from nagging, bullying, hectoring and other causes of irritation and anxiety.

Often, however, the sequence of events is less clearly defined and one of the greatest benefits derived by a firm from having its own safety organization is that an enquiry into the causes of an accident can be held shortly after it has happened. The statement is often heard that, whatever excuse may be made for an accident happening once, there can be no excuse for another accident of the same kind happening. Frequently, however, it is almost impossible to ascertain why a particular accident did happen. The evidence of eye-witnesses is often, perhaps usually, unreliable—particularly if previous to giving evidence they have had an opportunity of discussing with their mates what they saw and think they saw. Some persons will give quite sincerely an account of an accident which actually they did not see at all. And there are also some persons who have no scruples about telling lies in reply even to questions about accidents.

In some cases in which an individual has caused an accident by allowing his attention to wander from his job, the disturbing ideas, although dynamic, have been repressed into his subconscious system. The diagnosis then can be made only by a medical psychologist.

### **Stupidity and perversity.**

This brings me to the third heading—accidents which seem to be attributable to lack of concern on the part of the persons who caused them. Accidents of this kind are so stupid that one's first reaction is to wonder whether the levels of intelligence of the individuals concerned are not below average. No doubt inability to apprehend the risks being taken does sometimes lead to accidents. But I should not like to emphasize this point. I have known several men of high intelligence who were extremely dangerous drivers of automobiles, and I have been told of very capable lorry drivers whose level of intelligence was quite low.

A fundamental element in much recklessness is the desire to "show off," possibly before others, but perhaps merely to gratify a personal longing for superiority. The craving for speed which causes many accidents may be explained in this way. There are, however, other factors, such as the slapdash way in which some persons approach everything they do.

The fact that some accidents are attributable to perversity is distressing, but its existence has to be admitted. Highly contra-suggestible people frequently act in manners opposite to those suggested to them. This involves them at times in running serious risks. Such people often have a record of selfishness, insubordination, grumbling, rebelliousness and quarrelling. They are inclined to be

dissatisfied with their jobs, complaining about their friends, and difficult in their home life.

Sometimes they develop anti-social tendencies. The sense of social responsibility is not highly developed in everyone and, while few persons would consciously do anything to maim their fellows, there are some who are lax in the precautions they take to avoid hurting them. This may be observed in the casualness with which they behave after they have involved others in an accident. No doubt in many instances this is merely a pose to hide a keen feeling of guilt. But not always.

That directs attention to what is undoubtedly the worst feature of the subject of accident prevention. It is that frequently the person who suffers the consequences of an accident is not the person who was responsible for its happening.

### Discussion.

MR. R. C. FENTON (Section President): You have heard Mr. Oakley's talk on a subject which, as he says, affects a great many of us. No doubt you were, as I was, somewhat staggered at the figure of 50% of the population of the country suffering from some sort of accident each year, and I was trying to cast my mind back to the people I have been intimately connected with—for instance in the office; how many times has the first-aid cabinet been in use during the period of a year? And I am amazed to find I can remember almost every member of my staff having had a little iodine put on this, or a plaster put on that, things which very often we do not look upon as accidents, but which are accidents, and are the small things that lead probably to bigger ones; 50% of the population or 20,000,000 accidents a year is a staggering figure.

Mr. Oakley has certainly put forward some very interesting points under the eight headings, and if you know these eight headings, and you have a suitable person who can get on to an accident quickly after it has taken place, he could go very logically about making an enquiry along those lines, and I believe we should get somewhere on accident prevention.

MR. H. THORNELOE: I have often wondered, and perhaps Mr. Oakley may be able to tell us, why a hand file seems to be a magnet to human hands in the fitting shop? On the other hand, I have found it is only true of people who have received their training in later years, such as men who have left the Army at twenty-eight and gone into the shops and have achieved their master status, but they have always got this funny little habit.

MR. OAKLEY: Actually all these points really raise the same question; that is, what is to be done about the human tendency to be contra-suggestible, or to do the opposite of what seems to be

the reasonable thing? We have to accept the fact that there are many contra-suggestible people about. We have probably all had business contracts at various times with people who always take the opposite view to our own. Often associated with contra-suggestibility is an intense desire for superiority—perhaps over some other people, perhaps over all other people.

The desire for superiority may affect situations as well as people. So many young men, when they get their first car, want to drive at a terrific rate.

Why in some particular instance hand files should attract people as a magnet seems to be a problem for the works concerned. It may be that particular stress has been placed on its dangers, and so ideas have been put in the minds of contra-suggestible people.

MR. THORNELOE: I wondered whether it might not be legarthly on the part of the individual, and how to overcome it?

MR. OAKLEY: The question of laziness is a very wide subject. Indeed, five or six possible explanations could be given of a man's laziness, and of these contra-suggestibility is only one. I do not know, however, whether I would agree that lazy people are particularly prone to doing dangerous things. I should think that lazy people often show a good deal of discretion. Personally I should be more concerned about the restless, jumpy people who cannot settle down at a job.

MR. F. C. WHITE: I was very interested in your remarks regarding temperature. In the last few weeks, in order to increase our output we have increased the temperature of the factory, which, in these last few weeks, has been a very difficult undertaking, and we have succeeded in raising the temperature to approximately 65°, which is warm for the type of weather. Yet we have had three of the most serious accidents that we have had for two years.

I am just suggesting that these accidents were possibly due to those people having caught a chill, and were due to the cold weather and not due to the cool temperature at which the person is working. In other words, these people may not have completely worked off the numbness; although they may be in a warmer temperature that may really have an adverse effect on them.

MR. OAKLEY: There are two or three different ways of looking at that. Actually 65° is perhaps a few degrees too high at the present time, because temperature inside a factory has always to be related to the temperature outside. Also, in raising the temperature attention has also to be given to air movement. You might find another factor which is responsible for these accidents, quite apart from temperature. No conclusion could be reached, however, on the basis of three or four accidents.

This is a question which is being discussed a great deal at the

present moment because in some factories the blacking-out has interfered with the ventilation arrangements.

MR. WHITE : The factory is situated in a 40-acre site among woodland and reservoirs, and for another thing we have had the factory shuttered for the black-out. It was during the daylight hours when these accidents took place, and they took place in normal lighting.

The factory is heated by means of fans which mix the air inside, causing circulation. Also, due to the fact that we are exposed to the weather on four sides, I can assure you there has been plenty of ventilation.

MR. OAKLEY : I hope that is correct, but, as you know, we have our own methods of measuring ventilation. In any case you are not justified in attributing the cause of three accidents to ventilation. There may be an entirely different explanation.

MR. WHITE : I quite appreciate that. I mentioned it from the point of view that it was quite possible that the weather, not the cool temperature, was the cause.

MR. OAKLEY : You may be correct in attributing the accidents to numbness due to cold weather conditions. I cannot say.

There are so many other factors to consider. For instance, were the workers all physically fit at the time ?

MR. WHITE : We had an epidemic of German measles, but all the accident people were thoroughly healthy.

MR. GRIFFITHS : Mr. Oakley said something about distraction, stupidity and perversity. I am one of those Safety First men who believes that if you want to prevent accidents you must look after things that are likely to cause them. Some time ago, as I was going round the works, I noticed one of the floor boards was broken. A man was working on an adjoining machine, and he had only to tread on one side and down he would go. I called his attention to it and asked him to put something across so that nobody could come past, until I could get it repaired. I gave the millwright instructions and went back into my office. About half an hour afterwards a message came along that an accident had happened in the shop. It was the very man whom I had asked twenty minutes before to avoid that hole. I do not know whether we should call that stupidity or perversity.

To go on to a question raised by Mr. Oakley, and which I am very interested in, that is with regard to juvenile workers, it is common knowledge that a special committee was appointed to deal with accidents to juvenile workers. You will remember that at a meeting with a deputation from the Home Office an agreement was entered into whereby the employers would do their best to try and prevent the alarming number of accidents occurring to young people. The increase, I believe, was in the region of 25 per cent.

Our people took that matter up very earnestly, and I am glad to say we are on the safe side, and our juvenile accident figure is quite low.

We have had during the last ten weeks somewhere about two hundred young people. I find that these young people are put on carelessly. Nobody cares about them, so long as they get these boys and girls. I am satisfied that the Education authorities can assist us very considerably here. I think we have not made the progress this last twenty-five or thirty years that we ought to have done in this direction. When I was up North I had an arrangement with the headmaster of the Board School that when he sent boys into the works he sent a note with each boy saying, "This lad is likely to be very good at so-and-so." It was really wonderful how that helped. I think it would be better if the Education authorities here sent a suggestion with the boys and girls from their centres as to what they are most likely to succeed at, because they have had those boys and girls for a number of years, and they are likely to know the kind of work they are suitable for. It would be helpful to industry to get information of that kind.

MR. OAKLEY: I was under the impression that the Birmingham Education Authority was the shining example in Great Britain in supplying employers with information as to the qualities of boys and girls leaving school. You certainly appear to have more Juvenile Employment Offices than elsewhere.

The question of safety education in schools is often raised. One sees in picture papers photographs of children at school being taught the traffic rules. That is obviously of benefit, but the question is, how much further can you go? Just how can children twelve or thirteen years of age be taught safety methods in schools? We have to avoid the very common mistake when discussing education of saying that because it is desirable to know something it ought to be taught in schools. The problem is to know how to teach it.

With reference to your remarks on the way young people are starting in industry, I am in complete agreement with you. Even today it is true that a lot of boys and girls are put on surprisingly dangerous work. I served my own apprenticeship in a Clydeside shipyard. You see youngsters doing incredibly dangerous things. They are just showing off. It is one thing to say, "Stop them showing off," but another thing to know how to stop them. As far as I am concerned, safety education in schools is a thing which has my fullest support, but I want to know how it can be done, and I do not think anybody has ever succeeded in answering that question.

MR. E. T. COOKE: Speaking as a man who has been nearly all his life in works, if we were to take those eight points and make some analysis of each accident as it occurs with reference to those

eight points, we might constitute some kind of reconstruction which would enable us to get a little closer to the question of what causes such accidents. Referring to this question of how we are going to prevent accidents, I am one of those people who believe that nearly all accidents are avoidable. Accidents are caused by the state of mind of a particular man at the time the accident occurs, and his early education.

Referring to the question of the early education of youngsters in "safety first," I think that is the very last thing we ought to do. I do not want boys to grow up into "safety first" individuals. On the contrary, the boy who walks on high girders is the young man I want to see as an Englishman. We had better see that young man has such early training that he shall be able to associate cause and effect. That, I think, is most important. First of all, I say get off the "safety first" idea, but let them try to develop a logical frame of mind which would link up these two, then you have gone a long way to prevent that child from becoming an accident-prone individual.

Referring to the question of illumination, it does happen that I am rather an oldish man and have had to drive about four hundred miles a week in the black-out. It also happens that I have been interested in electric lighting from the technician's point of view, and I should be the last man in the world from that point of view to depreciate the modern tendency for more and more light. The thing that really matters is not the total light, it is the question of relative light. If you have got the correct relative illumination you can work with the aid of one single candle, providing it is relatively brighter than the other surroundings, the light from which falls on our eyes. So I suggest this question of relative illumination is the most important, and not really so much that of total light. You can be blinded by a torch on the road giving a relatively small light which is yet enough to prevent you from seeing the person who wanders across the road.

To a similar extent, I think those remarks also apply to the question of noise. It happens that the factory in which I have been working during the last five years has possibly produced more noise than any factory in the country. I have had a man come to me as an accountant, a highly sensitive man, one would think, who could only do his work under conditions of quiet. That man has been working within about twenty feet of a test room where horns have been sounding on and off all day long. At the end of the first week he asked for a better office. Owing to financial limitations it was not possible to arrange this immediately, and I asked him to stay where he was another month and then come back. He did not come back.

The real fact was that, just the same way as we have evolved

resistance to various things which tend to destroy life, so this man developed an automatic resistance to this noise, but if there should be another noise, not so loud but different in pitch and frequency, that will cause the man very great trouble. It is the difference in noise which tends to make a person more subject to accident than he would otherwise be.

MR. OAKLEY: The point about the state of mind is one in which I am in considerable agreement. But, as I said before, so many factors have to be taken into consideration. There is a great deal in what you say about safety first among children, with which I agree. Whether "Safety First" was a particularly good slogan seems to me to be very debatable, but at the same time I think one has to recognise that it has been put across very successfully. Everybody in this country is familiar with the slogan "Safety First," and has some sort of idea what it means. I agree with you entirely about the undesirability of making people frightened. Frightened people, as I indicated before, are to my mind more likely to have accidents than other people. That is why I mentioned, just incidentally, that perhaps the sort of slogan we have in mind is, "Caution when caution is needed."

I agree that we should speak about illumination in relative rather than in absolute terms and that high illuminations do not always lead to increases in output. But I do not think that even moderately fine work could be done at only one foot candle.

The subject of noise is one which interests me very much. The noises I had in mind when referring to accident causation were sudden, shrill, distracting noises. The question of the distraction caused by general noise bristles with controversies. We are agreed that all kinds of noise distracts people who are doing work calling for close concentration, and people doing very fine skilled work. At the same time there is no doubt a great many people do become accustomed to the noises in their working environment and cease to notice them.

MR. BRAMLEY. Mr. Oakley raises a point concerning the study of a job, is it being done in the wrong way, and rather suggests that it is important it should be done in the right way.

I am not going to suggest that it should not be, but I would like to point out that an operation which is based on some study of relative movement may create a rhythm, and I think that in that rhythm there is danger. If you take presses, most of the men are working in rhythm with the press, and then some irrelevant happening takes place the press continues to work to the rhythm and the man does not. That is when accidents take place. I think that is an important point. It may be best to have a machine which breaks the rhythm rather than tends to keep it, in the interests of safety as against the interests of production.

MR. OAKLEY : I think that an extremely sound point. Whether the suggestion of breaking the rhythm of a machine is equally sound I would not care to say.

MR. BRAMLEY : Perhaps one might call it a compound rhythm rather than a simple rhythm. If a man is performing more than just one action, he is not so liable to fall into the trap.

VISITOR : Arising out of that last question, I should like to ask the speaker how much he thinks speed accounts for accidents, and if that risk is particularly prominent when people are working on piecework ? Secondly, if he can say how long an operator is generally on a job before an accident occurs ? I wonder how much monotony has to do with distraction, and if periodic change of machine would add to the operator's caution rather than leaving him to rely entirely upon the rhythmic monotony ?

MR. OAKLEY : Mr. H. M. Vernon, formerly an Investigator for the Industrial Health Research Board, believed that speed is a very important factor indeed in accident causation, and was concerned about the consequences of the constant increase going on in the speed of industrial production. How long the operator is on the job is to some extent related to the point about distraction.

In the heavy industries, a different accident curve is found for the day shift as compared with the night shift. In the case of the day shift the accident curve tends to get higher towards the end of the day, whereas in the night shift it tends to be highest at the beginning of the shift. A probable explanation is that the man on the day shift comes to work in the morning, he has just got up, and during the day his mind begins to wander to the pleasures of the evening still to come, so that the distraction is greatest towards the end of his working day. The man on the night shift has already had his day and the distraction tends to be highest at the beginning of the shift ; there is nothing very much to look forward to.

The question of monotony is an extremely difficult one, as industrial psychologists well know. As one speaker has indicated although a job looks monotonous it does not necessarily follow that the person who is doing it finds it dull.

Some years ago, in 1930, I surveyed a good many factories in Birmingham looking for absolutely repetitive work which would enable reliable output curves to be drawn when research investigations were being carried out. I did not find one such job in Birmingham. The variations in many instances may seem very trivial, but they might be a source of considerable interest to the person who is doing the job. You may think it rather pathetic that a person could be interested in trifles, but if you are not in a position to suggest an improvement it is better not to criticise them.

The other point you mentioned was about changing workers from machine to machine. I am afraid a great many people have been

extremely disappointed when making such changes, for they were resented not welcomed.

VISITOR : You spoke about the length of time on the machine. I actually meant the length of time they had been on the job. Have you found that accidents generally happen when they are put on the machine at first or when they have been on them for some time ?

MR. OAKLEY : That is the case with youngsters. A factory inspector has published some deplorable statistics showing the number of boys who are injured often within a few hours of starting on a job. I suppose that does depend on the job to a certain extent, but generally they do tend to have accidents when starting a new job. But we are astounded when a man who has done a job for thirty years has an accident.

VISITOR : I wonder if Mr. Oakley could give us any information on the fact which I believe is commonly accepted that accidents commonly occur in cycles. I think we find that a factory will go on for months without an accident, and suddenly a crop of them occur. Is there any psychological connection between the first accident and the subsequent ones ?

MR. OAKLEY : Those accidents are largely the result of suggestion. A good deal has been said already about upsetting people and making them frightened. That is why, in the building trade, if a man is killed on a job all work is stopped for the day. The mere suggestion that an accident has happened will probably make some other people, who may be somewhat accident prone anyhow, much more likely to have an accident.

MR. THORNELOE : How would Mr. Oakley reconcile that with the fact that during the last war every time there was a crash in the air the whole squadron had to go up immediately ?

MR. OAKLEY : That is so, but it is not necessarily contradictory. That is a matter of doing a very dangerous job. The idea is that they will not brood on what has happened.

MR. BAYLISS : Can you tell me if you have had any experience in the application of music to industry ? It may be rather comical to some people, but it is definitely applied for increased production, during some times of the day. Would you say that music makes people alert and less prone to accident, or would they tend to lethargy ? Would the music, again, tempt them to be out of time with the job and thus cause accident ?

MR. OAKLEY : That is an interesting point. Some two or three years ago in an address at Sheffield I made reference to music in industry and spoke of some remarkable results that have been achieved. This was taken up by the press with enthusiasm. The idea is not to play music all day, but to play it for an hour in the morning and perhaps an hour in the afternoon. The music that is most

successful in my experience is martial music with a simple, steady rhythm, but according to the Industrial Health Board certain kinds of dance music are most successful. Clearly music in industry is only suitable for repetitive and monotonous work. If people have got to concentrate, they are likely to regard music as a distraction. After the war you are likely to see an organised campaign directed towards developong the use of music in British factories.

MR. LAKE : I rather think that the last speaker asked the question, would music be likely to cause accidents? I may be wrong about that. If so, the answer, which was certainly a boost for music, did not touch on the question of whether it was likely to lead to accidents.

MR. OAKLEY : I replied by implication. The distraction is most likely to come into highly skilled work calling for concentration.

MR. LAKE : If I may make another remark, the eight points have been rather forgotten in the last few questions. The psychologists are anxious that those eight points should be generally adopted in the future in accident reports. If a Welfare Superintendent or Safety Officer gets a call to an accident, he tries to lay his finger on the particular one of those eight points and put it against the accident. I want to know what the physchologist is going to do about it assuming they get this information. It is easy enough after some investigation to come to a conclusion as to how the man met with the accident, but what is to be done about it?

I think that in the modern factory eighty per cent of the work is definitely monotonous work. The man's mind is probably on something else most of the time, unless he is absolutely a skilled worker. The only thing that just about saves him from death from boredom is thinking about something else. I should be interested to know what the psychologist proposes to do about this problem of the man's state of mind. Frankly, I am a little worried about that. I do not see that much can be done about it.

Most of the speakers tonight have been talking about hard common sense facts, such as illumination, ventilation and temperature. I do not think psychology comes into it at all. A gentleman here admitted that he did not know what psychology was, and I do not know either. I endeavour to keep the idea of safety to the fore in a big aircraft factory near Birmingham. We have recently had the coldest spell we have ever known, and, apart from looking after safety, any man or woman who has got any complaint is encouraged to come along to the office and make it there. Complaints about cold have been simply terrible. They are justified—it has been perishingly cold, but we have not had any increase in accidents. Some parts of the factory are comfortably warm, but I do not think their figures show any great difference as regards accidents as com-

pared with those where people are always complaining of the cold. Again, I do not think that has much to do with psychology, but is rather in the same category as the question of temperature.

You might divide our factory up into three noise standards very easily : the pressing department, where the noise defies description ; the main big assembly shop where the noise is shattering but nothing like the pressing department ; and another shop where it is all peace and quiet. I cannot honestly say I know, or could quote you hard statistics to prove there is any big difference in the proportion of accidents throughout those three different noise departments.

**MR. OAKLEY :** With reference to the last half of your questions, you will find these statistical records do exist. Some of the points I have made are more closely related to industrial physiology than to industrial psychology but the two applied sciences overlap considerably. But I do not know how you put noise outside the sphere of psychology.

However, on the question of what is going to be done with these eight points, I did think it is necessary for me to develop this theme to this audience. What we are trying to do is to get a better form of analysis. When somebody is inquiring into an accident, he has got to have a plan in his mind. Admitted, after he has made his enquiries he will very frequently find he cannot do anything about them ; that was the gist of my concluding remarks ; but he can do a great deal along some of these lines.

**MR. KING :** It seems to me there is a big danger from the point of view of lighting. If we increase the lighting in very local areas for specially fine work, we are running a big danger of a general depreciation in the standard of eyesight as a nation. If we are always used to a comparatively bright light at work we shall want a brighter light at home and a better light in the street, which is all right if you stick to the town, but I do not think the time will ever come when you will have a bright light all over the country at night.

From the noise point of view, surely there is just as much danger in a sudden cessation of noise, particularly when it is general background noise, as there is from the sudden application of a stray noise ?

I should like to know if statistics bear out the old adage that familiarity breeds contempt ? Where there are accidents to older persons, can they be put down to familiarity ?

**MR. OAKLEY :** With reference to eyesight, I am afraid I do not agree at all. You have to remember that artificial lighting, in spite of the brightness that man has achieved, does not approach the brightness of the sun. We have to remember that only during the last couple of hundred years have we begun to work under artificial light. Man's natural adaptation is to sunlight. Think what a remarkable achievement that adaptation is. For instance, we

have learned to read and to write by artificial light in such a short time.

In the past it was said that the use of spectacles was going to ruin the eyesight of children. On the contrary, they make it easier for people to see. I do not think that by providing them with spectacles you are harming their eyesight—you are preventing their eyesight from being harmed.

Your question of unexpected cessation of noise is quite a sound point. The sudden switching off of background noise does attract attention. But it has not the same effect as a sudden shrill noise, and I emphasize this point because, in all the controversies about noise which have been raging in this country and other countries for the last ten to twelve years, there is agreement on one point. It is that a man is naturally disturbed by a sudden, shrill, unexpected noise. Please do not think I am one of those persons who are advocating noise abatement. Perhaps you will have guessed from my remarks that my own point of view about the control of noise are not dissimilar to your own.

On the subject of familiarity breeding contempt, I think it is quite possible. When a man feels on top of a dangerous job perhaps he becomes careless. That is a factor causing accidents, just as unfamiliarity with a dangerous job might also cause an accident.

MR. LAKE: There was a point brought up early in the lecture which seemed very interesting and which has not been touched on yet. I should like Mr. Oakley to tell us if the psychologists hope that one day the psychological test he mentioned in connection with public vehicle drivers and members of the R.A.F. in this country and others should be applied to the ordinary factory worker. I rather think that is the idea. If it is I think it is something we ought to be very careful about. I think the usual view is that it is a pretty hectic experience being driven by Paris taxi drivers. They do, I suppose, pass a psychological test, and so do members of the Royal Air Force, but any insurance man simply hates the sight and sound of a car driver who has any connection with the R.A.F. and sticks an extra premium on him straight away, and yet he is well able to pass almost any psychological test arranged by man. Mr. Oakley did quote the case of the somewhat backward lorry drivers in New York who are good drivers inasmuch as they are not accident-prone. That is a most important point if the psychologists are going to make tests of the ordinary working man.

MR. OAKLEY: I have not advocated the use of tests of accident-proneness in industry at the present time—that might come—but what psychologists are advocating is their application in their selection of transport drivers.

If there had been a Frenchman in the audience he would have leapt at you crying, "You see what our French taxi drivers can do.

Can your British drivers do as well?" I think that is one of the biggest tributes to Professor Lahy's method.

I agree with you about the accident-proneness of R.A.F. men. Some of them are not allowed to drive cars at all. It is a case of temperament, not a case of their absence of co-ordination—as a rule it is remarkably quick. The fault is in the temperament rather than in the ability.

MR. THORNELOE: I should like to endorse the remarks about the French taxi drivers, and if you go further afield to Milan they have much less accidents than we do, though they drive at a much more rapid pace. Their traffic has nothing like the evenness of flow that one finds in London. In London one is more or less expected to follow a slow stream, but in France it is one batch of traffic after another dashing along, and yet I have never seen anything worse than a wing touch in about ten years.

MR. R. C. FENTON: The various questions that have been put and the answers which have been given remind me of two cases of accident which I came into contact with. Both accidents were almost of a similar character in that the person was walking either in the darkness or semi-darkness and trod into a hole.

In the first case the man was on top of a brick kiln. He had gone up rather late and had the misfortune to step into one of the fire-holes. In that particular case his reflex actions were very quick, and he was able to throw himself forward and got off with nothing worse than a grazed knee. In the other case a man had gone into the shop in the dark where a channel had been made to put a cable in. He had stepped into the channel and had gone down rather heavily, breaking his leg.

It seems to me those are two good examples of what happens when a reflex action takes place. One man takes a grip on himself, the other man is slow in grasping what is happening, and by the time he has grasped it he has gone too far to stop himself. It would be very interesting if we could only get these two men on that test which is given to the taxi drivers and see how they reacted to it. It does show that a man who will react better to a test of that description may stop himself when an accident does take place.

MR. COOK: On the question of monotony, I rather fancy that we are looking at that question from the wrong angle, that monotony is rather a quality of mind of the individual and not of the particular job. We associate monotony with something that appears to us monotonous but which is by no means monotonous to the person doing it because they have not the monotonous kind of mind.

MR. OAKLEY: Monotony is one of the words we tend to misuse, just like the word "skilled." When we talk about "skilled work" we ought to talk about the worker who is skilled. There is no

monotonous work. There is no work which would be monotonous to everybody in Great Britain.

MR. R. C. FENTON : I am sure we are all very grateful indeed to Mr. Oakley for giving us something to think about, and something that we can apply not only to our business, but perhaps to our everyday life. It goes further than accidents that happen in the factory and their prevention.

One cannot help thinking that lots of accidents might be prevented by a little sympathetic treatment, a few sympathetic words sometimes which will set people's minds at rest.

MR. I. H. WRIGHT : I am entirely in agreement with Mr. Oakley as far as he has gone in psychology in the paper, and I am sorry that in the last part of his answers to the discussion he rather discouraged us from thinking there is ever going to be any system of testing elementary reactions to sudden noises and that kind of thing. I think something of that kind could be quite feasible.

Mr. Oakley deserves our very best thanks this evening for a most interesting paper. We have already complimented him by having a lively and vigorous discussion.

## THE EFFECT OF REVERSING FLAT LEATHER BELTS.

### Hair Side versus Flesh Side.

*By D. F. Galloway, Wh.Sc., B.Sc., Assistant Director of  
Research Department.*

#### Introduction.

**I**N many machine shops to-day, output is limited and the use of modern tools is precluded not by lack of machine capacity, but by deficiency in the power transmitted to the machines. In normal times production engineers may prefer to increase output by the introduction of new plant, but these times are not normal and machine tools are not easily obtainable so that it is essential to make full use of existing plant. To attain this end, each individual machine must have an adequate power supply, and since more than 70 per cent of the machines in use are still driven by belts from line shafts, it is essential that these belts should be capable of transmitting the power for which the machine tool was designed. Much heavier cuts could often be taken on machine tools if the belt drives were properly used.

In time of war it is essential that the utmost use should be made of every available machine tool, yet many machines are still utilising only a fraction of the power for which they were designed. The production engineer can do much to remedy this by ensuring that belt driven machines have the maximum power the belts will transmit. The inefficiency of many existing machine tool drives is due chiefly to belts running too slow and to driving on the flesh side instead of the hair side.

A 10 H.P. lathe (fig. 1) with belt speeds between 1,400 ft. per min. and 1,700 ft. per min. was tested in the Research Department and found to have an output of only 6.5 H.P. The belts were then reversed so that they were driving on the hair side instead of the flesh side, and an increase of approximately 35 per cent of the power available at the workpiece was observed. In order to ensure that this remarkable increase in power transmission was due solely to reversing the belts and that no ill effects ensued, the following tests were conducted.

- (1) Tests to compare power transmission by new belts driving on flesh sides and hair sides.

- (2) Tests to compare power transmission by used belts driving on flesh sides and hair sides.
- (3) Observations to determine whether driving on the hair sides of belts has any effect on the durability of the belts.

### Arrangement of Equipment and Method of Tests.

The belt B (fig. 1) was placed on the middle diameter of the three step cone pulley so that it linked two 14 in. diameter pulleys, while the belt A linked a 12 in. diameter driver to a 16 in. diameter counter shaft pulley. The average speed of belt A was 1,650 ft./min., and that of belt B 1,450 ft./min. The arcs of contact of the belts on

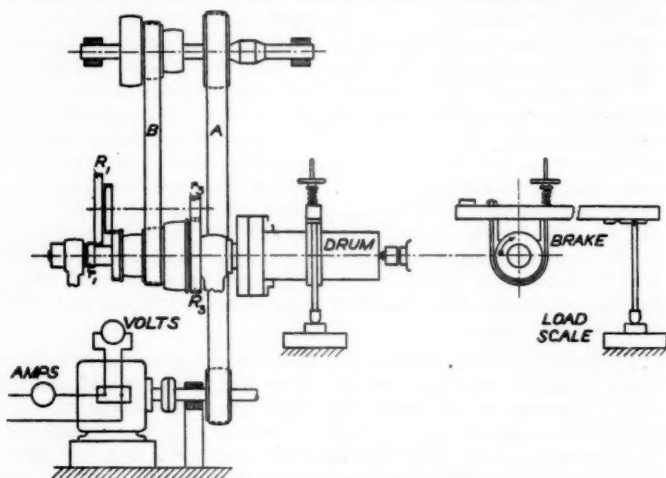


Fig. 1. Arrangement of equipment for test

each of the four pulleys were approximately  $180^\circ$  and the straight lengths of each belt were inclined at approximately  $25^\circ$  to the vertical. The work spindle was driven through the medium back gears, *ie.*, referring to fig. 1,  $R_1 r_1$  in mesh, and  $R_2$  and  $r_2$  in mesh.

The Brake Horse Power was measured by a prony brake which restrained a large cylinder held in the chuck and supported on a running centre. The machine was run with both belts driving on the hair side and the brake load reduced so that the spindle speed was approximately 100 r.p.m. The motor speed, spindle speed, brake load, amperes and volts were noted for a series of values of brake load. The procedure was then repeated with both belts driving on the flesh side.

# THE EFFECT OF REVERSING FLAT LEATHER BELTS

As the belts used in this first series of tests were comparatively new, the whole procedure was repeated with belts which had been "run-in" for approximately 50 hours extending over a period of about 3 weeks.

RESULTS OF TESTS WITH USED BELT  
TABLE I

FLESH				HAIR			
Slip %	Output h.p.	Input h.p.	Effi'cy %	Slip %	Output h.p.	Input h.p.	Effi'cy %
0	.1	1.1	9	0	.5	1.4	30.5
0	.38	1.7	23	0	1.5	2.8	53.5
.2	1.0	2.2	46	.6	2.2	3.7	59.5
.4	1.9	3.1	61	1.0	3.3	5	66.2
.8	2.9	4.4	66	2.3	5.1	7.8	65
2.3	4.1	6.2	66	7.2	8.2	13.6	60
4.8	5.8	9.3	63	*9	8.3	14	59.5
*8	6.7	11.3	60	10.0	8.5	14.9	58
10.0	6.8	11.6	59				

\* Interpolated.

## Results of Tests.

The results observed in the tests on used belts are shown in table 1. By subtracting the observed spindle speed from the speed for no slip, the slip was determined and expressed as a percentage of the speed for no slip. Graphs were plotted showing the percentage total slip of belts A and B after the above "running-in" period (fig. 2). From this graph it is clear that flat belts are capable of

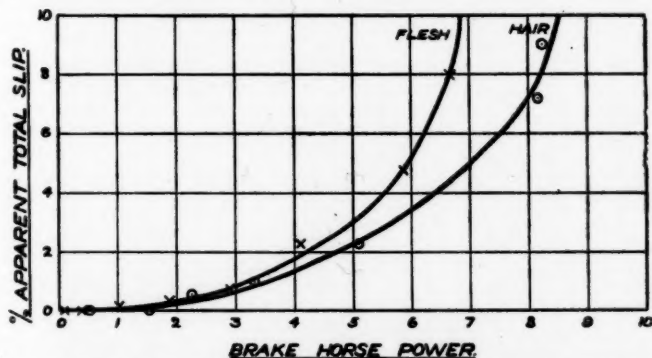


Fig. 2. Relation between apparent total slip and brake horse power for used belts.

transmitting much more power when driving on the hair side than when driving on the flesh side. It is well-known that after a reasonable "running-in" period the driving capacity and efficiency of belts improves. This fact accounts for the considerable increase in power transmitted which was observed as the belts were "run-in." However, whether the belts are new or well used, driving on the hair side instead of on the flesh side always effects an increase in the capacity for power transmission.

### Observations on Durability.

Obviously the effect upon durability can only be determined by observations extending over a long period. The Research Department has not yet had time to complete such observations within its own laboratory, but the records and present condition of belts regarding which reliable information is obtained, confirms the fact established 40 years ago by F. W. Taylor that flat leather belts have greater durability if used with the flesh side outside and the hair side driving on the pulley face.

### Conclusion.

From the results shown above, the general effects of reversing belts so that the hair sides are in contact with the pulleys are obvious. One immediate effect already mentioned is that an increase in power available for metal removal facilitates the use of modern cutting tools, even on comparatively old machines. In the case of the machine upon which the tests were made, the increase in power input from 6.8 H.P. to 9.1 H.P. for used belts (Table 1) resulted in an average increase in cutting power of approximately 35 per cent. The corresponding increase in cutting force had no ill effect upon the machine, for the principal parts such as gears, spindle, bearings, etc. were originally designed to withstand the stresses imposed by the higher power output.

Another advantage is that in some cases smaller belts can be specified for a given power transmission. Finally, the advantage of increased durability must not be overlooked, especially on belt drives linking small pulleys such as are frequently used on machine tools. Provided belts are kept clean and well dressed, their working life is often doubled by driving on the hair side, and even after years of correct use they exhibit no tendency to crack.

